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ON THE MARINE MIDGES OF THE GENUS *CLUNIO* HALIDAY
(DIPTERA, TENDIPEIDAE)

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The purpose of this paper is to describe five new species, to present a revised key to the males, and to give biological notes on certain of the new species in the genus *Clunio* Haliday. Three of the new species were collected by the junior author in the Hawaiian Islands, and the other two were collected in Florida and in the Galapagos Islands, respectively. The discovery of this genus in the United States and in the Galapagos Islands is of particular interest, the genus not having been reported previously from the New World. Because of their small size and unusual and restricted habitat, species are infrequently collected, and it is probable that they will be found to be much more generally distributed along the ocean shores than is now reported.

The genus *Clunio* was proposed by Haliday (1855) for the species *marinus*, which he described from Ireland. Since that time *marinus* has been recorded from England, France, and Egypt (= *syzyialis* Chevrel 1894, *bicolor* Kieffer 1901, *marinus* var. *aegyptius* Kieffer 1925), and there have been described: *adriaticus* Schiner 1856 (= *adriaticus* var. *balearicus* Bezzi 1913) from the Mediterranean; *pacificus* Edwards 1926 from Samoa, Japan, the Ryukyu Islands, and the Marianas Islands (Oka 1930, Tokunaga 1938a); *africanus* Hesse 1937 from South Africa; *setoensis* Tokunaga 1933 from Japan and the Ryukyu Islands (Tokunaga 1938a); *tsushimensis* Tokunaga 1933, *tsushimensis* var. *minor* Tokunaga 1933, and *aquilonius* Tokunaga 1938a from Japan, and *takahashii* Tokunaga 1938 from Formosa. The only previously described species seen by the authors are *pacificus* and *africanus*, the information contained in this paper for the other species being derived from the literature. The two most useful papers are the full historical review of the genus up to 1913 by Bezzi, and Tokunaga's (1935) detailed account of the biology of the Japanese species. Williams (1944, p. 170) published the first records of this genus from the Hawaiian Islands, figuring the

female pupa, male and eggs, but he did not name the species.

The ratios used in this paper are not all based on the same unit of measurement, so they cannot be used to indicate the relative size of the different species. They are also based on a single specimen, usually the holotype in the case of the males, and do not represent the mean of variation. Likewise, the drawings, even of homologous structures, are not necessarily drawn to the same scale.

The types of the new species here described are deposited in the United States National Museum. Paratypes have been presented to the United States National Museum, the Bernice P. Bishop Museum, the British Museum, the California Academy of Sciences, and the South African Museum.

CLUNIO Haliday

Clunio Haliday, 1855, Nat. Hist. Rev. 2: 62.

Edwards (1929) has given the most satisfactory definition of the genus *Clunio* to date, but as some of the species described since then do not fall within the limits set by Edwards, while obviously belonging to the genus, it is proposed to modify Edwards' diagnosis as follows:

Male.—Eyes pubescent (except in *schmitti*). Clypeus and vertex without setae. Mouthparts reduced, the maxillary palpus consisting of a single small segment. Antenna 11-segmented (8-segmented in *takahashii*), almost bare, the basal segment or scape (antennaria of authors) triangular, the second or pedicel large and bulbous, the third or post-pedicel or first flagellar segment elongate, segments fourth through penultimate subspherical, and the distal segment long and slightly clavate. Pronotal lobes small, widely separated, bare. Mesoscutum robust, emarginate anteriorly and overhanging the head, bare except for a few setae in each subdorsal row and supra-alar patch. Wings well developed, rather broadly rounded and petiolate, the anal angle prominent, surface without microtrichiae, the fringe rather long, squama bare. Venation: R_1 rather indistinct, variable in length; R_2 ends well before wing tip; costa not produced; r-m short; M straight or slightly upcurved distally; cubital fork at or slightly beyond r-m, Cu_1 nearly straight, Cu_2 curved caudad; M, Cu_1 and Cu_2 usually atrophy before wing margin, anal veins atrophy at about level of fCu. Legs stout; tibial spurs single (absent on fore and mid legs in *brevis*); tarsi short, first segment two to three times the second, second to fourth broader than long except on hind legs, where third segment is about twice as long as broad and swollen dorsally; fifth segment cordiform and larger than preceding segment; the claws simple, stout and strongly curved, each with a hyaline lamella and usually with a tuft of hyaline setae on ventral side; pulvilli absent; empodium as large as claws, thickly plumose, forming a large pad arising ventrally between the claws and curving upward and backward. Genitalia large, at least half the total length of abdomen, rotated

through 100-180°, the tergites appearing ventral and sternites dorsal. Basistyles enormously enlarged, often immovably fused mesad for most of length; the ninth tergite forming a large pubescent median ventral plate conically produced distally into a median nipple—or knoblike titillator; the penis opens above, flanked by two thin lateral sclerotized lips which are connected to a pair of arcuate heavily sclerotized parameres piercing the mesal sides of the basistyles. The dististyles are folded inwards in repose, flattened, arcuate or triangular in profile, the mesal corner with a small tooth and distolateral angle usually with several minute retrorse spines. Vestiture of genitalia of fine pubescence except for a few long hairs on caudomesal margin of basistyles.

Female.—Head small, the eyes pubescent, with the facets reduced in number; antenna bare, short, appearing to be 5 or 7-segmented, the scape reduced. Mouthparts reduced. Wings and halteres absent, the legs being the only sclerotized structures of the thorax; these short, tibial spurs absent, first four tarsal segments very short, fifth moderate, not bilobed, the claws stout, curved and simple, with lamellae; empodium reduced. Preapical abdominal segments setigerous, seventh sternite with a prominent transverse patch of setae; last two segments pubescent only. Cerei small, about as wide as long, folded mesad. Spermathecae two, oval, the ducts usually partially sclerotized.

***Clunio littoralis*, new species**

(Figs. 2, 9, 10, 21)

Male.—Length 2 mm.; wing 1.4 mm. long, 0.7 mm. wide. Color of freshly preserved alcoholic specimens: Vertex, pedicel of antenna, entire thorax except for scutellum, coxae, trochanters, articulations of femora and tibiae and of tarsal segments, and genitalia rich brownish; flagellum of antenna, wings, halteres, bulk of femora, tibiae, and tarsi, scutellum, and venter of abdomen milky yellowish white; abdominal tergites grayish, darkening on posterior segments; eyes and tarsal claws blackish.

Head: Interocular width at vertex about half total width of head and slightly less than eye height; eyes with facets small, the interfacetal spaces with dense fine hairs. Antenna (fig. 2) with the scape prominent and triangular; the pedicel bulbous, slightly longer than wide, somewhat narrowed on proximal end, without setae; third segment nearly five times as long as broad, slightly darkened at each end, with two small setae near middle; segments IV to X subequal, slightly longer than wide; distal segment clavate and somewhat flattened, swollen toward apex to almost twice the diameter of proximal segments, length subequal to preceding four to five and a half segments combined; segments IV to XI slightly infuscated, segments III to X each with a pair of hyaline sensory organs near apex; distal segment with numerous sensory pits; ratio of lengths of flagellar segments beginning proximad, 45:12:12:9:9:12:12:13:60. Maxillary palpus thumb-shaped, with the apex slightly darkened and bearing a few minute setae.

Thorax: Mesoscutum bare except for 7-8 small setae in each sub-

dorsal row and about 4 in each supra-alar patch; light spots surround the bases of these setae. Scutellum with about 14 short hairs, the longest of these about half the length of the scutellum; postscutellum and pleura bare.

Wing (fig. 21): Appearing smoky brown by transmitted light, milky white by reflected light; radius with a few minute setae, membrane bare; anal lobe rather acutely rounded and situated well toward base of wing, making the stem of the wing rather short for *Clunio*; wing widest at distal third. Wing fringed with fine hairs, bare toward base of costa, hair of costal margin curved and dense, those posterior to wing tip straight and alternating short and long, gradually lengthening toward anal angle, where they are decidedly long. Vein R₁ rather long, more than two-thirds the length of R₄; the latter almost straight, ending in costa at most anterior portion of wing beyond which wing margin curves posteriorly to apex; veins M, Cu₁ and Cu₂ each atrophied well short of wing margin; distal section of M rather straight at base, curved forward toward apex; Cu₁ in a line (which is slightly sinuous) with base of Cu, fCu narrow at base, Cu₂ gently curved proximad, sharply bent and re-curved at distal third or fourth.

Legs: Stout; coxae and trochanters each with but a few fine setae distally; fore femur and mid and hind femora and tibiae each with sparse rows of strong setae; tibial spurs all strongly curved apically, that on hind leg largest. Basitarsus about three times as long as broad on all legs; tuft of setae present on ventral side of claws. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Ta1	Ta2	Ta3	Ta4	Ta5
Forelegs:	8	5	13	17	3	1.4	1.4	1.1	2.5
Mid legs:	6	4	18	15	3	1.3	1.2	1.0	2.6
Hind legs:	7	4	20	17	4	1.6	3.0	1.2	2.8

Abdomen: A transverse row of 5-10 fine long hairs about halfway back across each tergite except on last segment which bears a sublateral patch of 3-4 on each side. Genitalia: Basistyles immovably fused mesally on proximal half, tapering strongly beyond to articulation of dististyles on laterodistal extremity; dististyle (fig. 10) flattened, broadly expanded and triangular in outline with the lateral margin thickened and slightly arcuate concavely; the apical angle rounded with two sharp retrorse spines on upper margin; the mesal angle about 90° but gently rounded with a large flat blunt cephalo-projecting tooth on margin just distad of angle; the pubescence of dististyle quite long, grading into extremely fine hairs toward base. Phallosome complex quite prominent, with the ninth tergite conically produced caudad to level of tips of basistyles and ending in a small, nipplelike, bare titillator. The penis projects upward through a large opening just caudad of fused portions of basistyles, with a lateral pair of sclerotized lips bare internally, pubescent externally, connected laterally with each basistyle by a strongly

sclerotized paramere which pierces the basistyle on upper aspect about midway of the caudomesal margin.

Female.—Length 1.9 mm. Yellowish white with the head, legs, and genitalia sclerotized and light brown; integument with scattered, irregular bluish pigment spots.

Head: Very small, triangular in anterior view with the vertex broad, clypeolabrum produced triangularly ventrad; eyes small, each with about 15 small widely separated facets. Antenna (fig. 9) apparently 5-segmented; the first segment (pedicel) about as broad as long, bare, brownish in color; second segment nearly twice as long as broad, constricted in middle; third and fourth segments subspherical, last segment about twice as long as broad, ovoid; distal four segments whitish, without setae, but segments II to IV each bear a pair of hyaline sensory organs near apices; ratio of lengths of segments beginning with the pedicel 7:12:6:6:10.

Legs: Short; coxae and trochanters relatively large, femora and tibiae short and stout; first four tarsal segments of all legs very short, much broader than long, fifth segment about as long as preceding 3 segments combined, not bilobed and with a pair of stout curved simple claws, these dark brown and without evident setae or lamellae; empodium present but vestigial. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Ta1	Ta2	Ta3	Ta4	Ta5
Forelegs:	37	23	45	35	5	5	5	5	15
Mid legs:	30	20	45	35	5	5	5	5	15
Hind legs:	27	20	50	35	5	5	5	5	15

Abdomen: Preapical segments unsclerotized, with a vesture of numerous small setae; seventh sternite with a transverse band of longer hairs. Ceréi flattened trapezoidal in outline, broader than long and broadest distally. Spermathecae brown, the ducts also sclerotized and brown half the length and curved back on the spermathecae.

HOLOTYPE, male, Waimanalo, Oahu, VI.15.1946, W. W. Wirth; ALLOTYPE, female, Kahuku, Oahu, I.1946, W. W. Wirth (mounted on slides). PARATYPES: Oahu: 2 ♂♂, Hanauma Bay, I.4.1946 (WWW); Koko Head, 2 ♂♂, VI.25.1946 (WWW), 6 ♂♂, VIII.27.1946 (WWW); 5 ♂♂, Waimanalo, II.15.1946 (WWW), 28 ♂♂, 6 ♀♀, Lanikai, XII.1945 (light trap at beach), 1 ♂, 1 ♀ *in copulo*, Kaneohe Hospital, X.25.1945 (light trap, 2 miles inland); Kahuku, 44 ♂♂, 2 ♀♀, I.1946 (light trap near shore), 9 ♂♂, II.8.1946 (WWW); 11 ♂♂, Waimea, XII.21.1945 (WWW); 1 ♂, Maile, I.8.1946 (WWW). Hawaii: 12 ♂♂, Hilo, IV.22.1946 (light trap near bay shore). Kauai: 1 ♂, Nawiliwili, IX.8.1946 (WWW, at light); 7 ♂♂, Wailua, IX.8.1946 (WWW). Except as otherwise noted all material was col-

lected from rocks between tide marks at the seashore; all females were taken *in copulo* with males.

Clunio littoralis seems to be the most widespread of the Hawaiian species. The immature stages were not discovered, but the males with the wingless females attached were often taken while flitting over algae-covered rocks exposed at low tide where doubtless breeding occurs. This species has never been taken on shores exposed to quantities of fresh water. A male *Clunio*, from those reported by Williams (1944, p. 171) from Midway Atoll, collected in June 1941, was examined through the kindness of Dr. Williams and appears to be *littoralis*.

C. littoralis is closest to *marinus* and *aquilonius* which it resembles in the sharply curved vein Cu_2 and short terminal antennal segment. *C. marinus* differs from the present species, however, in the very short vein R_1 (less than a third the length of R_s), the markedly up-curved vein M, and the dististyles with recurved mesal angle; and *aquilonius* differs in the shorter R_1 (about a third the length of R_s), the vein Cu curved through its entire length rather than abruptly recurved beyond middle, and the absence of retrorse teeth on distal angle of dististyle.

Clunio vagans, new species

(Figs. 4, 7, 8, 13-19, 23)

Male.—Length 1.5-2 mm.; wing 1.5 mm. long, 0.7 m. wide. Color of freshly preserved alcoholic specimens: Vertex, pedicel of antenna, entire thorax except for scutellum, coxae, trochanters, articulations of femora, tibiae, and tarsal segments, and genitalia rich brownish; third and last antennal segments whitish, intermediate segments infuscated, especially toward apices; wings, halteres, scutellum, and bulk of femora, tibiae, and tarsi yellowish white; preapical abdominal segments grayish, darkening on posterior segments; eyes and tarsal claws blackish.

Head: Interocular width at vertex much less than half the total width of head and slightly less than eye height in anterior view; eyes with the facets small, the interfacetal spaces large and clad with dense fine hairs. Antenna (fig. 4) with scape prominent and triangular; pedicel bulbous, about half again as long as broad and slightly tapering distad, without setae; third segment about four times as long as broad, slightly darkened at each end, with two small setae before distal third; segments IV to X subequal, and about as broad as long; distal segment very long but length variable, longer than preceding seven segments combined, slightly clavate distally; segments IV to XI without setae; III to X each with a pair of hyaline sensory organs near apex; distal segment with numerous minute sensory pits. Ratio of lengths of flagellar segments beginning proximad, 43:11:10:9:8:9:9:9:75. Maxillary palpus unseg-

mented and thumb-shaped, the apex infuscated and bearing a few minute setae.

Thorax: Mesoscutum bare except for about 3 small setae in each sub-dorsal row and about 5 in each supra-alar patch; these arising from light-colored ocellate spots. Scutellum with 12 short hairs, the longest of these about half the length of scutellum; postscutellum and pleura bare.

Wing (fig. 23): Appearing smoky brown by transmitted light, milky white by reflected light; radius with 10-12 minute setae, membrane bare; anal lobe more or less acutely rounded, stem of wing rather short for the genus; wing widest at distal third. Wing fringed with fine hairs, these sparse toward base of costa, denser toward apex; on posterior margin of wing the fringe consists of alternating long and short hairs gradually lengthening toward anal angle where they are rather long. Vein R₁ short, about a third the length of R_s, which is straight, meeting the costa toward wing tip, and subequal in length to proximal section of R; distal section of M almost straight, not up-curved; M, Cu₁, and Cu₂ all atrophied just short of wing margin; fCu rather narrow at base, Cu₁ slightly sinuous, Cu₂ distinctly but gently curved through entire length; 1st and 2nd A atrophy at about level of fCu.

Legs: Stout, coxae and trochanters each with a few long fine hairs distally; femora and tibiae of all legs with sparse rows of fine setae, those of front tibia short; tibial spurs all moderately curved apically, that on hind pair slightly the largest. Basitarsus about twice as long as broad on all legs; tuft of setae present on ventral side of claws. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Ta1	Ta2	Ta3	Ta4	Ta5
Forelegs:	6	4.0	12	19	3.2	1.2	1.0	1	3
Mid legs:	6	3.2	16	14	2.5	1.0	1.0	1	3
Hind legs:	6	4.0	16	16	3.0	1.2	2.5	1	3

Abdomen: A transverse row of 5-15 long setae about halfway back across tergites I to V, sixth tergite with a row of 5 setae along posterior border on each side, seventh with 3 setae on each side in corresponding position. Genitalia: Basistyles immovably fused mesally on proximal third, tapering strongly beyond to articulation of dististyles on latero-dorsal extremity. Dististyle (fig. 8) flattened, broadly expanded upward and inward and triangular in outline with the lateral margin thickened and slightly, concavely arcuate; apical angle rounded with one or two minute retrorse spines on upper lateral margin; the mesal angle is about 100° and broadly rounded, with a large, flat, appressed cephalo-projecting tooth on margin just distad of angle; vestiture of dististyle of very fine minute hairs, mesal angle bare. Phallosome complex prominent, the ninth tergite conically produced caudad to level of tips of basistyles and ending in a small bare flattened nipplelike titillator (fig. 7); surface of tergite densely pubescent. The penis opens above just caudad of fused portions of basistyles, the lips of the opening sclerotized laterally

and connected on each side by a heavily sclerotized arcuate paramere with the caudomesal margin of the basistyles; these parameres extend nearly straight laterally turning distally only slightly.

Female.—Length 1.5-2 mm. Yellowish white with the head, legs and genitalia sclerotized and light brown; integument with scattered, irregular bluish pigment spots.

Head: Very small, triangular in anterior view with the vertex broad, clypeo-labrum produced triangularly ventrad; eyes small, each with about 15 small widely separated facets. Palpi and mouthparts reduced. Antenna small, apparently 5-segmented; scape reduced; first segment (pedicel) about as broad as long, bare, brownish; second segment about 2.5 times as long as broad; third and fourth segments subspherical; last segment about twice as long as broad, ovoid; distal four segments whitish, without setae; segments II to IV each with a pair of hyaline sensory organs near apex; ratio of lengths of segments beginning with the pedicel 9:18:8:8:14.

Legs: Short; coxae and trochanters relatively large, femora and tibiae short and stout; first four tarsal segments of all legs very short, much broader than long; fifth segment about as long as preceding three segments combined, not bilobed; the stout, simple, curved claws dark brown and without evident setae or lamellae; empodium short, extending but slightly beyond base of claws; legs bare of setae except for a few on outer side of tibiae. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Ta1	Ta2	Ta3	Ta4	Ta5
Forelegs:	45	30	60	52	5	5	5	5	17
Mid legs:	42	28	60	50	5	5	5	5	15
Hind legs:	40	28	66	50	5	5	5	5	15

Abdomen: Preapical segments unsclerotized, with a vestiture of numerous setae; seventh sternite with a dense transverse band of similar setae. Cerei flattened, triangular in outline, the bluntly pointed apices directed mesad. Spermathecae sclerotized and brown, the ducts slightly curved and lightly sclerotized for about a third the length of the spermathecae.

Larva.—Length (mature) 4-5 mm., head capsule about 0.3 mm. long by 0.2 mm. wide. Body whitish, head capsule and hooks of pseudopods sclerotized and light amber.

Head oval, widest at posterior third, roundly tapering and downcurved forward, flattened slightly in cross section; integument quite smooth. Frons long, two-thirds of total length of head, the median arm of epierianial suture an additional one-sixth and the clypeolabrum the other one-sixth of length of head. Frons widest midway of length, roundly pointed caudad at junction of frontal sutures, truncated anteriorly by the frontoclypeal suture which is half as long as greatest width of frons. The antennae (fig. 16) are borne laterally at ends of frontoclypeal suture; each is about half the length of this suture and five-segmented; the first segment is barrel-shaped, about half again as long as broad, and about

three times as broad as second segment; second segment slightly longer than first, about three times as long as broad, cylindrical and bearing at the apex the peglike third segment which is about a fifth as long and a third as broad as second; fourth and fifth segments minute, spinelike, together about as long as third, the fifth about half as long as fourth; first segment also bears a fine hair on the side and at apex a prominent Lauterborn's organ as long as distal segments combined, biramous midway, the proximal portion cylindrical and lightly sclerotized, the distal arms bladeliike and hyaline; apex of second segment also bears several long setae and fine hairs. The clypeolabrum is about twice as wide as long and rather crescent-shaped, the anterolateral margins thickened; without median sclerites; bearing a lateral pair of fine hairs on anterior margin. A pair of submedian setae are borne in the frontoclypeal suture and two pairs of fine long setae on lateral margins of anterior half of frons. The vertex bears a pair of very irregular dorsolateral eyespots each consisting of a large posterior spot and a contiguous small anterior spot just laterad of frontal suture at anterior third of head; there is a pair of fine setae just ventrad of eyespots, a pair of fine setae just caudad of eyespots with a pair of seta-less tubercles just mesad adjacent to frontal sutures at level of posterior frontal setae; a pair of fine setae adjacent to frontal sutures about midway between eyespots and posterior junction of sutures; and a pair of seta-less tubercles on each side of the median posterior arm of the epicranial suture.

Labrum as seen from below emarginate anterolaterally in an overhanging lip, the lateral sclerotized bridge being continued mesoposteriorly forming a submedian articulation for the paired triserrate premandibular appendages and forming a median epipharynx with numerous setae, spurs and pegs as figured (fig. 17). Mandible (fig. 15) rather slender, with 5 blunt teeth on distal third, with 2 long setae on ventrolateral margin and a brush of about 6 long feathered hyaline hairs on dorsal side toward base. Maxilla (fig. 14) membranous, bilobate distally; the lateral lobe bears 2 long setae about midway; at apical margin a very short 3-segmented palpus with minute sensillae on basal segment, the distal segments minutely spinelike, and an adjacent palpuslike sensory disc with minute apical sensillae; mesal lobe bears in order a fringe of 2 bluntly rounded fringed scalelike projections, a stout flattened hyaline bladeliike spine, 2 capitate and about 5 sharp long setae, and a mesal hyaline comblike projection; ventral surface bears several sensory pegs and there are 2 long setae near base between the lobes. Mentum (fig. 13) transverse and heavily sclerotized, with a large rounded median and 4 pairs of smaller and slightly shorter lateral teeth; a lateral pair of plumose hairs arises near base. Hypopharynx membranous, supported by 2 small lateral sclerites, the transverse lobe between fringed with a beard of fine hairs.

Thoracic and preapical abdominal segments without evident setae. Prothoracic pseudopod shallowly bilobed at tip, each lobe with a crown of hooklets ranging from minute retrorse spinules on posterior side to

long slender hook-tipped spines minutely serrate on concave side of anterodistal margin. Last (ninth) abdominal segment rounding dorso-posteriorly, with a pair of short stout pseudopods borne ventrolaterally; about 15 strongly curved unserrated hooks in 3 irregular rows at apex, those of distal row much the longest and least curved; a pair of long fine hyaline hairs are borne on dorsoposterior extremity of ninth segment, another pair are borne just below on a pair of blunt moundlike caudal protuberances; there is another pair of small blunt hyaline protuberances just anterior to anus between the pseudopods which may be vestiges of anal gills.

Male pupa.—Length, 2-2.8 mm.; exuviae sclerotized and pale amber throughout. Cephalic region short, broadly emarginate anteriorly, with the long antennal cases arising laterally, curving posteriorly over the eyes and extending caudad along dorsolateral margins of thorax to level of bases of wing cases; a submedian pair of short setae arise on dorsal margin of head between bases of antennal cases.

No trace of prothoracic respiratory organs; dorsum of thoracic region bears several submedian pairs and paired groups of minute setae; leg and wing cases extend caudad along the lateroventral side of body to level of third sternite; the wing cases lateral in position above the leg cases with the costal margin contiguous with the cases of the hind legs.

Abdominal segments transverse, slightly narrowing posteriorly; with transverse spinous bands as follows (figs. 18, 19): Tergite II with widely separated laterobasal patches of sharp spinules, tergites III-VII with complete broad basal bands of sharp spinules across anterior margin; tergites III-VII with a single row of strong recurved spines from posterior margin; sternites VI and VII with a row of smaller recurved spines from posterior margin; sternite VIII with a median oval patch of sharp spinules toward posterior margin; ninth segment reduced to a median dorsal lobe conically produced between the prominent sheaths of the gonostyles; at each lateral junction with the sheaths a pair of minaret-shaped spines. The sheaths of the gonostyles quite large, the lateral margins triangularly tapering mesad on caudal half, the apices each with a single blunt hyaline tooth.

HOLOTYPE, male, ALLOTYPE, female, Wailua Falls, Kauai, IX.4.1946, W. W. Wirth. PARATYPE, 8 ♂♂, 5 ♀♀, same data as type; 300 ♂♂, 10 ♀♀, Punaluu, Oahu, I.15.1946, W. W. Wirth; 36 ♂♂, 11 ♀♀, Hilo, Hawaii, III.2.1946, W. W. Wirth.

At Punaluu, Oahu, swarming was observed on the end of a large iron drain pipe about a foot and a half in diameter extending about 50 feet from the beach into the sea at a level which was just covered by the highest tides. A reef about a quarter of a mile off shore protected the beach from heavy breakers so that the wave action was relatively gentle. The pipe was thickly covered with a growth of algae, chiefly *Ulva*

sp., in which the *Clunio* were colonizing. The larvae and pupae were found in their silken nests among the bases of the algae. The females were also seen crawling about among the algae, and the males in their characteristic half-flying, half-running motion, with wings outstretched and vibrating rapidly, were seen to crawl into the algal growth seeking the females. At times the males would emerge from the algae and run or fly around with the females attached *in copulo*, much too small and helpless to impede the males' progress. The concentration of these midges on the algae-covered pipe was remarkably great, resembling those previously described for *C. marinus*, *adriaticus*, and *tsushimensis*, which at times appears "as if the rocks were covered with powdery snow seen at distance" (Tokunaga, 1935, p. 4). Several hundred specimens were easily collected in a few minutes by sucking them off the algae with an aspirator. Occurring with *Clunio vagans* on the pipe were numerous ephydriids, *Scatella sernotata* Cresson and *Canace nudata* Cresson, as well as a few of the predaceous dolichopodid, *Cymatopus acrosticalis* Parent.

At Hilo, Hawaii, the colony was found on a flat benchlike rocky expanse of several hundred square yards' area which was exposed at low tide just in front of the beach at the waterfront in Hilo Bay. These rocks were covered with a luxuriant growth of the algae, *Ulva* sp. and *Enteromorpha* sp., and received a considerable proportion of fresh water from an along-shore drift from the mouth of the Wailuku River. The Hilo breakwater afforded protection from heavy wave action. *C. vagans* males and females *in copulo* were taken in numbers from the algal growth at low tide, but were not swarming in tremendous numbers as in the Punaluu incident.

A most unusual and almost inexplicable occurrence of *C. vagans* was discovered at Wailua Falls, Kauai. The Wailua River is a rather rapid stream with a rocky bed about a hundred feet wide at the falls. The falls are located about 4 miles from the sea, the lower expanse of about 3 miles consisting of a rather broad sluggish tidal stream, while the upper mile below the falls forms a rapid with a drop of about 50 feet. The *Clunio* males with wingless females attached *in copulo* were observed flitting at the water line around the spray-drenched and ripple-washed boulders in the rapid where the water ran swiftest. As immature stages were not taken it is not known whether breeding occurred at this rapid or whether these numerous specimens had migrated all the way up from the sea. A search was made above the falls (height about 200 feet) for *Clunio* without success. One would hardly expect these small fragile midges to migrate in such large numbers up this particular stream from breeding places in the

sea, though such might be the present situation; on the other hand no species of *Clunio* has ever before been found breeding or even occurring in streams. No characters were found which would separate the specimens taken at Wailua Falls from those found breeding on the seacoasts of Oahu and Hawaii. If, however, a colony had become established in the stream and had been isolated for many years, one could expect speciation to occur.

There is a somewhat parallel situation in another genus of Clunioninae, the marine genus *Telmatogeton*, which in the Hawaiian Islands has succeeded in evolving at least five species in the torrential mountain streams. It may be supposed, whether *Clunio vagans* may be found breeding at Wailua Falls, or whether a large number had merely wandered up the stream, that here is a similar instance of a species trying to escape a distasteful environment to which competition had long ago forced its clunionine ancestors. In *Telmatogeton* we see the results of such a successful escape after many years; it is possible that in *C. vagans* we are witnessing the manifestations of the means by which such a transition was made.

C. vagans is intermediate between *pacificus* and *tsushimensis*, the three species forming a closely allied group quite similar in general facies and especially in antennal characters. Using characters of the wing and tibial spurs, however, the three species can be separated as stated in the key at the end of this paper.

Clunio brevis, new species

(Figs. 5, 12, 24)

Male.—Length 1.1-1.2 mm., wing 0.9 mm. long, 0.5 mm. wide. Color of freshly preserved alcoholic specimens: Head, pedicel of antenna, thorax and abdomen, including genitalia, brownish; the mesonotum and abdominal tergites darker; the pleura, scutellum, postscutellum, coxae, trochanters, and articulations of femora, tibiae, and tarsal segments light brown; flagellum of antenna, wings and halteres, and bulk of femora, tibiae, and tarsal segments yellowish white; eyes and tarsal claws blackish.

Head: Interocular width at vertex about a third of total width of head and a little less than eye height; eyes with facets small, the interfacetal spaces with dense fine hairs. Antenna (fig. 5) with the scape broad and triangular, the pedicel enlarged, about as long as broad at tip, markedly tapering at base, its greatest diameter slightly less than scape and about twice that of flagellar segments; third segment about twice as long as broad with 2 small setae about midway, segments IV to X subequal, each slightly longer than broad; distal segment short, not quite as long as preceding 3 segments combined, slightly flattened, its greatest width slightly greater than preceding segments; segments IV

to XI without setae, III to X each with a pair of hyaline sensory organs near the apex; distal segment with minute sensory pits. Ratio of lengths of flagellar segments beginning proximad, 21:10:10:10:11:11:11:31. Maxillary palpus unsegmented, rather long and fingerlike, about as long and thick as distal antennal segment, with a few minute setae.

Thorax: Mesoscutum full, the dorsum slightly carinate mesad, with the subdorsal furrows rather deep, each with 3-5 long fine setae; the shoulders full, 3 long fine setae in a row above each wing base. Scutellum with about 5 setae, these about as long as scutellum; postscutellum and pleura bare.

Wing (fig. 24): Appearing smoky brown by transmitted light, milky white by reflected light; radius with about 8 fine setae. Wing wide in relation to its length, broadest through the middle, anal lobe angulate, directed toward wingbase; stem of wing fairly long, nearly a fourth of total length of wing. Wing fringed with relatively long hairs, these sparse towards base of costa, shortest at apex of wing, quite long at anal angle; posterior fringe of alternating long and short hairs. Vein R_1 about a third the length of R_s , which is straight, meeting costa toward wing tip, and is slightly shorter than base of R ; distal section of M nearly straight, slightly upcurved, not quite reaching wing margin; Cu_1 gently downcurved through its entire length, atrophied slightly before margin; Cu_2 also gently curved caudad to meet wing margin; 1st and 2nd A atrophy at about level of fCu .

Legs: Stout, coxae and trochanters with a few fine hairs distally; femora and tibiae with a few sparse rows of fine setae, those of front legs much shorter than on mid and hind legs; tibial spurs absent on front and mid legs, on hind legs single, small, and nearly straight; apices of tarsal segments also with fine setae. Basitarsus about 2.5 times as long as broad on front legs and 1.5 on mid and hind legs; tufts of seta present on ventral side of claws. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Ta1	Ta2	Ta3	Ta4	Ta5
Forelegs:	5	3	9	12	2.8	0.8	0.8	0.8	1.8
Mid legs:	6	2.5	11	10	1.8	0.8	0.8	0.8	1.8
Hind legs:	5	2.5	12	11	2.0	0.8	1.8	0.8	1.8

Abdomen: Genitalia (fig. 12) rotated through 100-150°; about 8-10 long fine setae in an irregular transverse row about halfway back on tergites I-VII, VIII with 2 lateral pairs of long setae and about 8 in a medioposterior patch. Basistyles fused mesally at base, slender, gradually and slightly tapering to apex; mesal margin concave, with a fringe of very fine setae above, basistyles otherwise bare. Dististyles flattened lateromesally, arcuate with convex side mesad; in lateral profile they are almost semilunar, the lower margin thickened and slightly concave, the upper margin convexly expanded and bearing a flattened blunt tooth on outer side about midway of margin; distal apex slightly hooked downward with several minute retrorse spines on lateral aspect; vestiture of dense pubescence. Phallosome complex with the ninth tergite

produced caudad nearly to level of tips of basistyles, beneath with a narrow sclerotized longitudinal median line; distally the tergite is abruptly constricted and produced in a prominent knoblike titillator. On upper side of phallosome the lateral lips of the penis opening but very slightly sclerotized, opening just cephalad of the titillator; parameres very prominent, sclerotized and dark brown, broad, stout and sharply bent cephalad in middle; mesal ends almost contiguous just cephalad of penis opening, the flattened apices finely serrated into about 20-30 fine sharp spinelike teeth; lateral ends rodlike and produced through the mesal concavities into interior of basistyles about midway of their length.

HOLOTYPE, male, Waimanalo, Oahu, III.15.1946, W. W. Wirth. PARATYPES, 36 ♂♂, Waimanalo, Oahu, II.15.1946 (2), III.11.1946 (11), III.15.1946 (13), IV.11.1946 (10), W. W. Wirth, 1 ♂, Makapu Point, Oahu, V.1.1946, W. W. Wirth; 11 ♂♂, Koko Head, Oahu, VI.25.1946, W. W. Wirth.

All of the above localities are within about 5 miles of the coast line on eastern Oahu, featured by a rugged rocky coast without the protection of an outer coral reef. As this coast lies in the direct path of the northeast trade winds, the surf is very heavy. In each locality, *C. brevis* occurred in about equal numbers with *C. littoralis* from which it could readily be distinguished by its smaller size. Its habit of flight was similar to that of *littoralis*, possibly a little weaker. The males were collected at low tide. The females were not seen, but it is presumed that breeding occurred on the rocks covered with brown algae fringing the shore which were exposed at the lowest tides, but which were kept constantly drenched by the heavy waves.

C. brevis is a very much reduced form of *Clunio*, the smallest in the genus, and unique for the vestigial tibial spurs on the front and mid legs, the short broad petiolate wings, and genitalic structure, particularly the enlarged knoblike titillator, the arcuate dististyles, and prominent serrated parameres. The next smallest species, *takahashii* from Formosa, shows a reduction along a different line, the male antenna being only 8-segmented, there being only four short flagellar segments present, the species apparently otherwise normal except that the wings are also more petiolate. The close relationship of *brevis* to any known species is not apparent.

***Clunio marshalli*, new species**

(Figs. 3, 11, 22)

Male.—Length 1.5–1.75 mm.; wing 1.18–1.34 mm. long, 0.5 mm. wide. Color generally yellowish brown; vertex, mesoscutum, and genitalia darker; the legs except for the articulations of the segments, wings.

halteres, and abdominal sternites yellowish white; abdominal tergites with bluish gray pigment; eyes and tarsal claws blackish.

Head: Intercocular width at vertex about half total width of head and distinctly less than eye height; vertex broadly convex above with a distinct swelling on each side adjacent to tops of eyes. Antenna (fig. 3) with the scape triangular; the pedicel bulbous, about as wide as long and slightly wider than scape, about half as long and nearly twice as wide as the third segment which is about four times as long as broad, with 2 setae just beyond middle; segments IV-X from 1 to 1.5 times as long as wide, becoming longer distally; distal segment cylindrical or slightly swollen distally, slightly longer than the preceding 4 segments combined; apex of third and all of segments IV-X slightly infuscated, also each of these segments with a pair of hyaline sensory organs near apex, distal segment with numerous sensory pits; ratio of lengths of flagellar segments beginning proximad, 35:10:11:13:15:15:14:14:60. Maxillary palpus thumb-shaped, only slightly narrowed at base. Facets of eyes rather widely separated, the interfacetal hairs abundant, about as long as width of 1 facet.

Thorax: Mesoscutum bare except for 2-4 small setae from light-colored ocellate spots in each subdorsal row and 2-3 longer setae in each supra-alargroup. Scutellum with a pair of submedian and 1 or 2 pairs of lateral setae; postscutellum and pleura bare.

Wing (fig. 22): Radius with several small setae, membrane bare; anal lobe acutely rounded; wing fringed with fine hairs, bare on basal third of costa, these hairs progressively shorter toward wing tip and quite long toward anal angle. Vein R_1 a little less than half the length of R_2 , the latter nearly straight, ending in costa at most anterior portion of wing beyond which wing margin curves posteriorly to apex; distal section of M rather straight, only very slightly upcurved; Cu_1 in a straight line with base of Cu , fCu narrow at base, Cu_2 gently and gradually curved.

Legs: Coxae and trochanters unarmed; femora of forelegs and femora and tibiae of mid and hind legs each with several sparse rows of strong setae; tibial spurs with tips weakly curved, that of hind tibia large, half as long as basitarsus. Basitarsus longest on all legs, about twice as long as broad on fore—and mid legs and three times as long as broad on hind legs. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Ta1	Ta2	Ta3	Ta4	Ta5
Foreleg:	8	6	15	24	3.5	1.6	1.6	1.6	3
Mid leg:	7	5	19	17	3.0	1.5	1.5	1.2	3
Hind leg:	7	5	22	21	4.5	2.0	3.5	1.2	4

Abdomen: Sclerotized margin of eighth tergite with a semicircular indentation posteriorly. Genitalia large, the width at apex of basistyles equal to length of basistyles, these fused incompletely mesally on basal half, tapering strongly beyond to apex, caudomesal hairs moderately long. Dististyles flattened, triangular and scapuliform, the outer margin

thickened basally, the distal margin appearing folded over on lateral two-thirds, a few recurved spines on the rounded distolateral angle; the mesal angle rounded, with a small flat cephalo-projecting tooth on distal margin about a fourth way toward distolateral angle. Phallosome complex (fig. 11) with the ninth tergite produced to level of tips of basistyles, the broadly rounded apex with a small nipplelike titillator bare of pubescence, somewhat depressed into the extreme mesodistal margin. The penis opening flanked on each side by a pair of flattened, distally sclerotized, rounded liplike plates, the widely separated bases of which articulate with the parameres. The latter very heavily sclerotized and exceptionally sharply curved in a semilunar outline, the closely approximated, posteriorly projecting mesal ends finely dentate apically while the lateral ends pierce the basistyle on each side for about half their length, curving sharply caudad distally. The dististyle and ventral plate are decidedly pubescent.

Female.—Length 1.8—2.1 mm. Color yellowish white, with the head, legs, and genitalia sclerotized and light brown; abdomen with scattered patches of dark pigment.

Head: Small, about as broad as long: distance between eyes about twice the height of one eye. Eye small, round, prominent, each with 10-15 widely separated facets, the interfacetal hairs abundant. Antenna apparently 5-segmented, scape reduced, first segment (pedicel) globular and distinctly broader than distal segments, bare, brownish in color; second segment about twice as long as broad; 2 adjacent segments often fused; distal 4 segments without setae; segments II to IV each bear a pair of hyaline sensory organs near apex; ratio of lengths of segments beginning with scape, 20:30:15:15:30. Clypeolabrum projecting conically ventrad, the maxillary palpus a short lobe.

Thorax. The notum in profile broadly convex, extending forward over head; no scutellum visible.

Legs: Sclerotized and brown, the coxae, trochanters, apices of femora and apices and bases of tibiae darker; first 4 tarsal segments shorter than broad, the fifth swollen, twice as long as broad; claws nearly as long as fifth segment. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Tal	Ta2	Ta3	Ta4	Ta5
Forelegs:	10	6	10	11	1.5	1.5	1.5	1.3	4.0
Mid legs:	8	5	14	10	1.4	1.4	1.4	1.4	3.5
Hind legs	8	5	17	10	1.4	1.4	1.4	1.4	3.5

Abdomen: Membraneous except for seventh and genital segments, with a vestiture of numerous small hairs; seventh sternite and sides of seventh tergite with abundant long hairs. Cerci flattened and roundly triangular in outline, much broader than long and broadest at base. Spermathecae heavily sclerotized and brown, the ducts not apparently sclerotized.

HOLOTYPE, male, Biscayne Channel, Dade County, Fla., X.18.1945, Nelson Marshall; ALLOTYPE female and PARATYPES, 32 ♂♂ and 229 ♀♀, same data as holotype.

This species is named in honor of Nelson Marshall who first discovered it. Professor Marshall first saw the species "September 7, 1945, running around a conch partially exposed at low tide on the sand flats adjacent to Biscayne Channel." These were not collected, but "on October 18th they were observed dipping below the 3-inch waves along the water line of our boat and laying eggs on the barnacles there as the boat lay anchored in Biscayne Channel which is a good three-fourths mile from the nearest point of land" and some of these were collected. The barnacles taken from the boat were *Balanus amphitrite*, and in among the barnacles were tangled masses of egg strings in which both males and females of the *Clunio* were embedded. None of the specimens was *in copula*.

Clunio marshalli differs from *pacificus*, *tsushimensis*, and *takahashii* in having the last antennal segment much shorter than the preceding seven combined; it differs from *setoensis*, *marinus*, and *adriaticus* in having the first flagellar segment shorter than the distal segment. It is close to *africanus*, but *marshalli* differs in having the tip of the ninth tergite rather broad and emarginate so that the titillator arises from a depression, and the lateral prolongations of the parameres are turned sharply caudad.

Clunio schmitti, new species

(Figs. 1, 6, 20)

Male.—Length 2.5 mm.; wing 2.0 mm, long, 0.9 mm. wide. Color pale yellowish throughout, the genitalia slightly darker.

Head: interocular width of vertex not measurable in the specimen. Eyes with the facets very close together, the interfacetal spaces reduced and entirely without evidence of interfacetal hairs. Antenna (fig. 1) with the scape triangular, the pedicel bulbous, slightly longer than broad and slightly narrowed basally, subequal in diameter to the scape and about twice as broad as the third segment; the latter about five times as long as broad with a pair of setae near middle; segments IV to X subequal, each about 1.6 times as long as broad; distal segment somewhat swollen on basal two-thirds, markedly tapering distally to a small nipplelike tip, about four times as long as maximum breadth, broadest at proximal third; sense organs not apparent on flagellum, but these probably lost through over maceration; distal segment pitted. Ratio of lengths of flagellar segments, beginning proximad: 57:16:14:14:15:15:13:12:56. Maxillary palpus thumb-shaped, constricted considerably at base, with a few minute setae at apex.

Thorax: Mesoscutum apparently bare, the subdorsal and supra-alar

setae exceedingly minute. Scutellum with about 20 very fine setae; post-scutellum and pleura bare.

Wing (fig. 20): Widest at distal third, the anal lobe prominent and acutely rounded; wing fringed with very fine hairs but these reduced toward base of costa, the fringe becoming longer on posterior margin toward anal angle. Vein R_1 short, less than half the length of R_2 , the latter nearly straight, ending in costa just before most anterior portion of wing; distal section of M slightly sinuous proximally, markedly up-curved distally and atrophied before wing margin; Cu_1 nearly straight, atrophied about two-thirds the way from fCu to wing margin; Cu_2 straight proximally, sharply recurved at about 90° at distal two-thirds and then turned slightly toward wing tip, not quite reaching wing margin; fCu rather broad at base.

Legs: Coxae and trochanters unarmed; setae of remainder of legs very fine and inconspicuous; tibial spurs greatly reduced on forelegs, small with weakly curved tips on mid legs, and very short and heavy with a hooked tip on hind legs; spurs not at all darkened. Basitarsus longest on all legs, about four times as long as broad on forelegs, 2.5 on mid legs, and 3.0 on hind legs. Ratio of lengths of segments:

	Co.	Tr.	F.	Ti.	Tal	Ta2	Ta3	Ta4	Ta5
Foreleg:	11	9	22	35	6	2	2	1.5	4
Mid leg:	10	7	29	26	5	2	2	1.5	5
Hind leg:	10	7	30	28	6	2	4	1.5	5

Abdomen: Genitalia (fig. 6) with the width of the combined basistyles across the tips as great as length of basistyles; these fused along median line for about three-fourths their length, tapering strongly toward apex, the caudomesal margin being short and transverse with a definite, low protuberance and a patch of fine setae about midway. Dististyles flattened and scapuliform, the lower lateral margin thickened and slightly concave, the upper mesal margin angularly (about 100°) expanded and bearing a large, flattened, blunt tooth on outer side at the mesal angle; a prominent laterally projecting tooth on outer side at extreme distal angle of dististyle; ninth tergite rather narrow, the apex produced conically to about level of tips of basistyles and ending in a prominent nipplelike titillator; on upper side of ventral plate the sclerotized, rounded lips of the penis opening closely flank the titillator, while their bases articulate caudally with the arcuate, heavily sclerotized parameres; the latter have their flattened mesal tips closely approximated and extending caudad between the lateral lips of the penis opening nearly to their apices, while the lateral ends of the parameres pierce and extend laterally about two-thirds their length within the basistyles; the dististyles and the ventral plates are strongly pubescent.

HOLOTYPE, male, Narborough Island (Isla Fernandina), Galapagos Islands, I.14.1934, W. L. Schmitt. (Mounted on slide.)

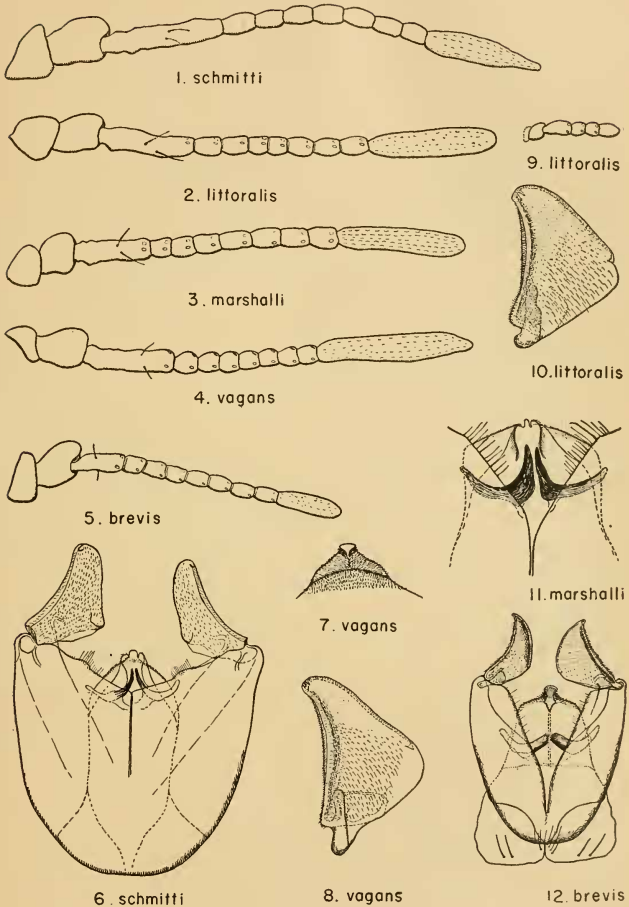


Plate 17. *Clunio* spp. Figs. 1-5. Male antennae. Fig. 6. Male genitalia, dorsal view. Fig. 7. Apex of ninth tergite. Fig. 8. Dististyle. Fig. 9. Female antenna. Fig. 10. Dististyle. Fig. 11. Phallosome complex, dorsal view. Fig. 12. Male genitalia, dorsal view.

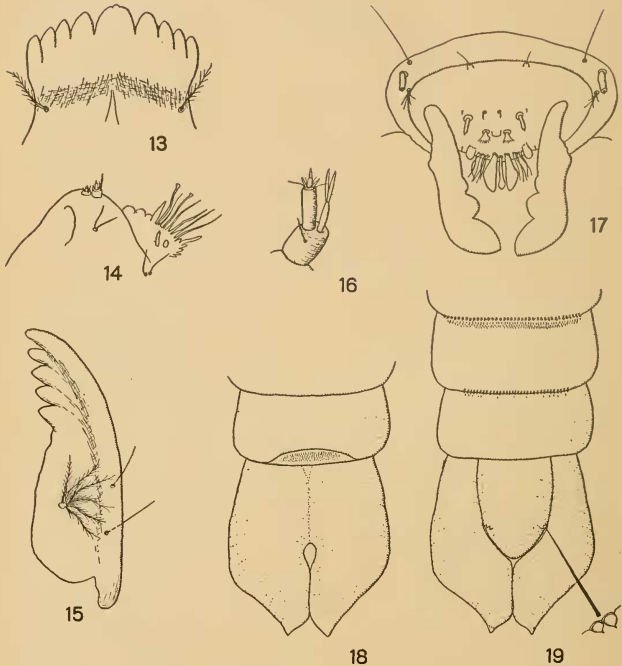
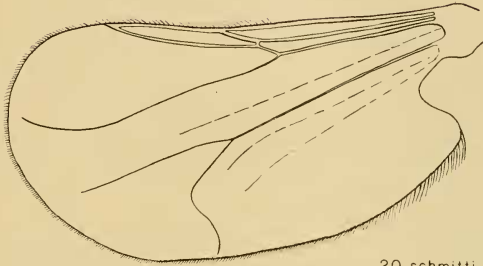


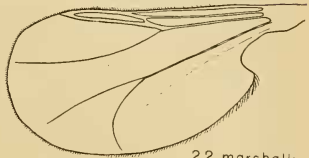
Plate 18. *Clunio vagans*, n. sp. Fig. 13. Mentum of larva, ventral view. Fig. 14. Right maxilla of larva, ventral view. Fig. 15. Mandible of larva, dorsal view. Fig. 16. Antenna of larva. Fig. 17. Labrum of larva. Fig. 18. End of abdomen of pupa, ventral view. Fig. 19. End of abdomen of pupa, dorsal view.



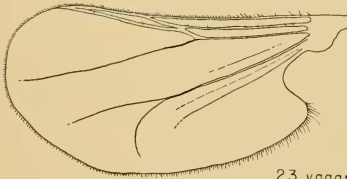
20. schmitti



21. littoralis



22. marshalli



23. vagans



24. brevis

Plate 19. *Clunio* spp. Figs. 20-24. Wings.

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